Research To Evaluate The Feasibility of Using Wetlands in a Water Quality Trading Program

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Why this work is important?

-More widespread implementation of watershed-scale trading could create opportunities to restore and construct wetlands as a means to generate pollutant reduction credits.

-Strategically located and designed wetlands could be used to improve water quality through the capture of nutrients and sediment, generating water quality credits that could be used by permitted dischargers to comply with NPDES permit limits.

-Taking full advantage of this opportunity could achieve water quality goals at lower cost while attaining the President’s goal to restore, improve and protect at least three million additional acres of wetlands.

Context: Historical Loss of Wetlands…

Significant losses of wetlands have occurred nationwide as a result of human activities

Despite progress in reducing loads of a number of Pollutants Of Concern (particularly point sources) to lakes, rivers, estuaries and groundwater over the past 20 years, the quality of aquatic habitats in many parts of the United States is still declining

Recent evidence indicates that 89% of the U.S. coastal estuaries show signs of impairment. (GOM Hypoxia)

Recognized Wetland Benefits

- **Important, diverse habitat for a wide range of organisms (both transient and permanent residents)**
- **Important hydrological sites (holding water and moderating the down stream effects of flooding)**
- **Important sites of biogeochemical activity (transform, cycle, sequester contaminants and nutrients)**
- **Key component in watershed restoration / management**

Strategic Approach

Evaluate the feasibility of using wetlands in water quality trading programs in a way that informs:

National Policy Development
and
Watershed Planning

Overall wetland research needs include

Gaining a comprehensive understanding of the role wetlands play in reducing and moderating stressors

Better scientific information on how to successfully restore, enhance and protect different kinds wetlands in different areas of the country

Understanding when and where wetlands can play a role as innovative cost-effective BMPs for both point source and nonpoint source controls

Gaining a better understanding of the role wetlands can play as part of a potential nutrient trading program

Priority Research Areas

- **Wetland Science**
  - **Develop templates for wetland types**
  - **Focus on two groups of wetlands**
- **Water Quality and Watershed Modeling**
  - **Predict / quantify / <u>verify</u> environmental benefits**
- **Economics Research**
  - **Understand drivers and incentives for wetlands in trading markets**
  - **Verify environmental benefits**
- **Decision Science**
  - **Use research to inform policy and decision-making**

Research Assumptions

- Yield net increase in quantity and quality of the Nation's wetlands
- No degradation of ecologically intact, native wetlands
- Quantify risk of unintended consequences
- Confirm environmental results via the collection of water quality data and data on ancillary ecological services

Study Design

Consider:

- Restoration of degraded or former wetlands
  - Return natural functions and services, with controlled or passive delivery of water to the system
- Wetland treatment systems
  - Wetland restoration as part of a constructed wetland project
  - Wetland restoration as part of a watershed or TMDL implementation plan

Approach

Conduct Feasibility Studies and Review the State of the Science

Technical Workshop to establish state of practice and identify research barriers to trading

Identify and evaluate ongoing wetland performance and trading projects and build partnerships, develop, deploy, test pilot projects

Economics Research Gaps

- ***Performance***: Are trading programs that incorporate wetlands cost-effective, can we increase participation and do these programs lead to actual pollutant reduction?

- ***Scale***: For a given water quality trading market, what geographical scale is most appropriate?

- ***Ancillary Benefits and Ecological Sevices***: Can they be used as market incentives; how do they affect water quality trading markets?

- ***Verification***: Methods used to assess, models?

- ***Cost of Unintended Consequences***: Invasive species, nuisance wildlife, greenhouse gases, pollutant tradeoffs (e.g., manage for N reduction, P increases; contaminants)

Wetland Science Gaps

- ***Performance***: **How does pollutant removal vary with respect to wetland type, morphology, landscape position?**

- ***Scale***: **What wetland size or area within a watershed will maximize performance?**

- ***Wetland Trajectory***: **How do function and performance vary with wetland age?**

- ***Verification***: **Methods used to assess, models?**

- ***Risk of Unintended Consequences***: **Invasive species, nuisance wildlife, greenhouse gases, pollutant tradeoffs (e.g., manage for N reduction, P increases; contaminants)**

Wetland Groups

Develop engineering templates and watershed scenarios to analyze project performance and market viability

- *Managed Wetland*: Diked Controlled Flow / Flow Augmented Off Channel Ponds
  - Upper Watershed Placement
  - Lower Floodplain Placement
- Large River Channel Restored Wetlands

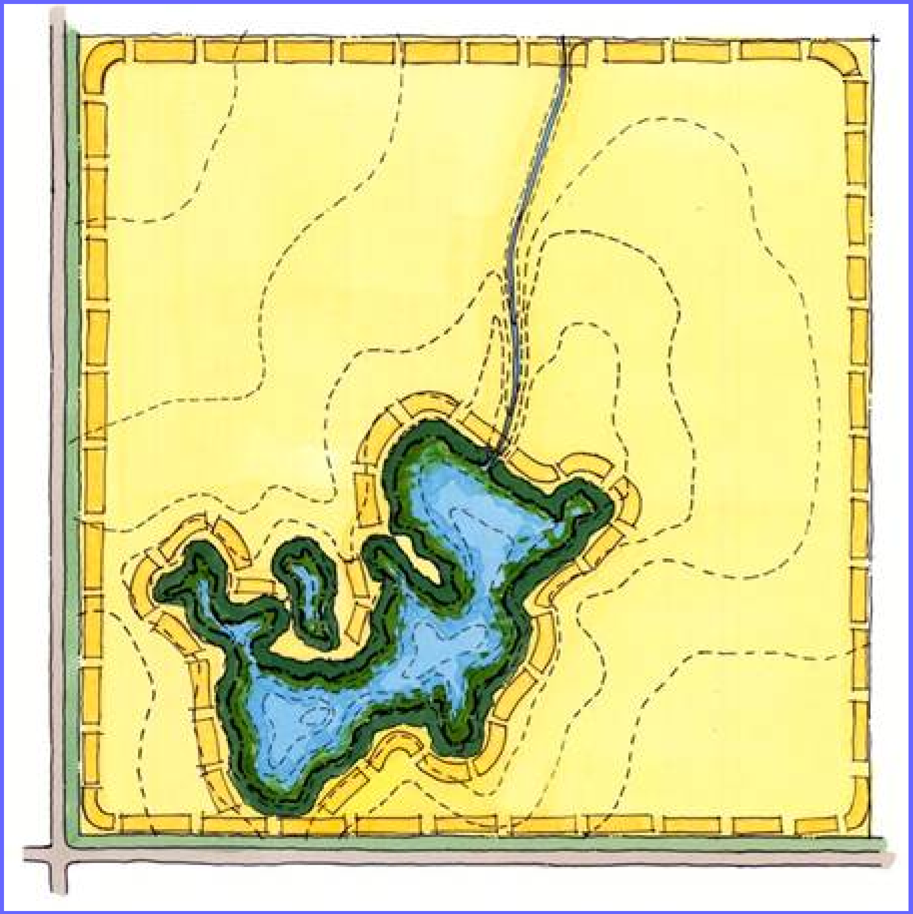
Other wetland groups:

- In Channel Low Order Stream Wetlands
- Coastal / Tidal Restored Wetlands
- Urban Depressional Wetlands
- Treatment Wetlands

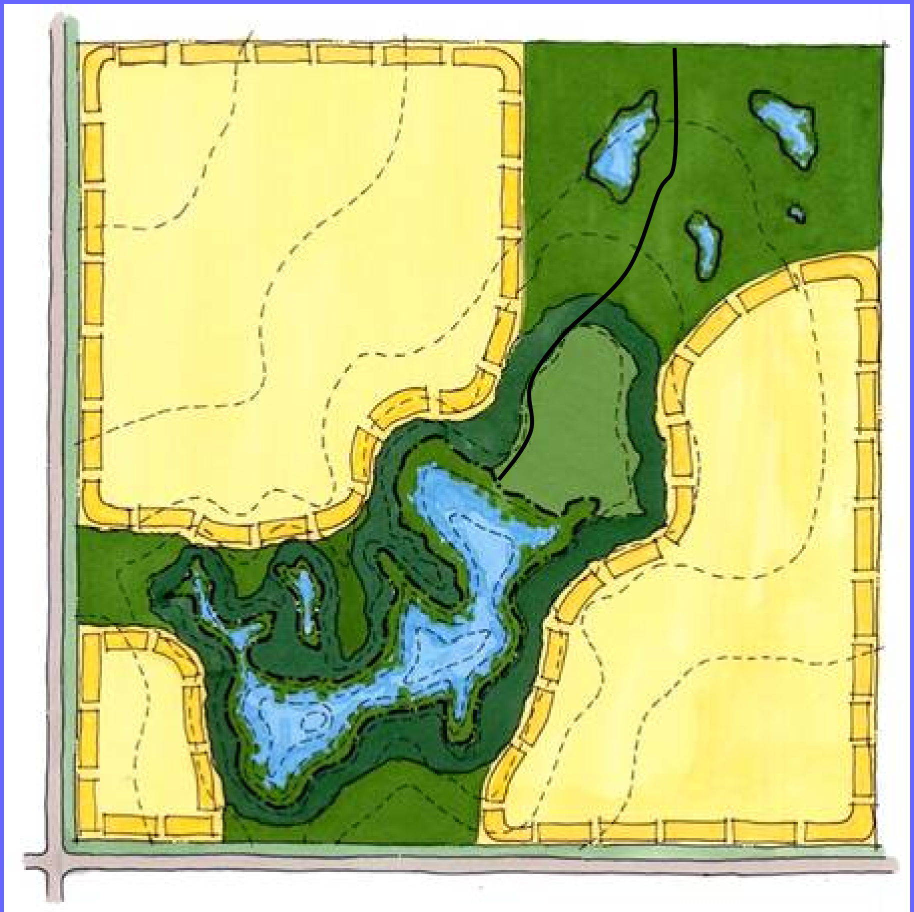
What is a Template?

example, along stream corridor:

Conventional



Conservation

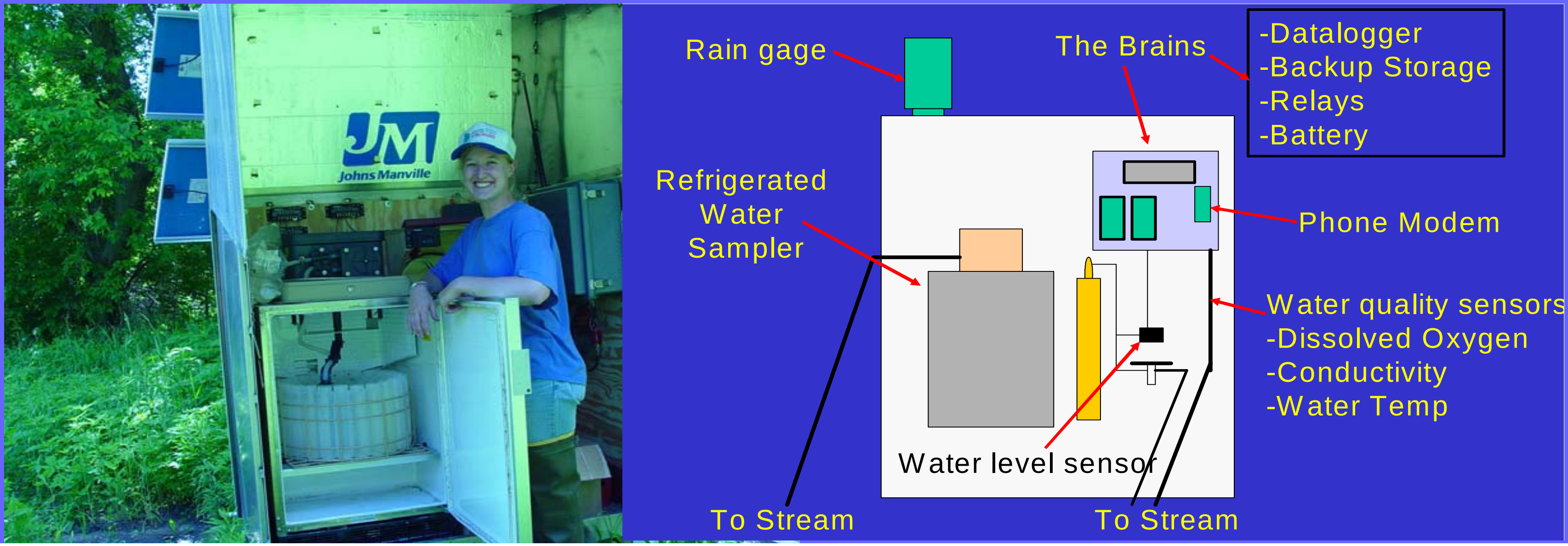


Project Example for Wetland Template along stream corridor, Conservation: Managed Wetland with Diked, Controlled Flow

Approach

- Characterize/ Monitor Hydrology Storm and Base Flow (ISCO's, Data Sonds, Acoustic Sensors)
- Develop Rating Curves for Sediments and N and P
- Characterize/Monitor Water Quality and Chemistry (ISCO's, Data Sondes, Laser In-Situ Scattering Transmissometers)
- Quantify Sediment Deposition/Attenuation (Sediment Core Dating: Historical and Annual Deposition, Clay Pads)
- Characterize/Monitor Sediment Quality and Chemistry
- Mass Balance (Sediments and N and P)
- Conduct Constructed Wetland Economic Cost Benefit Analysis
- Develop/ Test Wetland Assessment Methods

Load estimates: Automated sampling of water for nutrients and discharge.

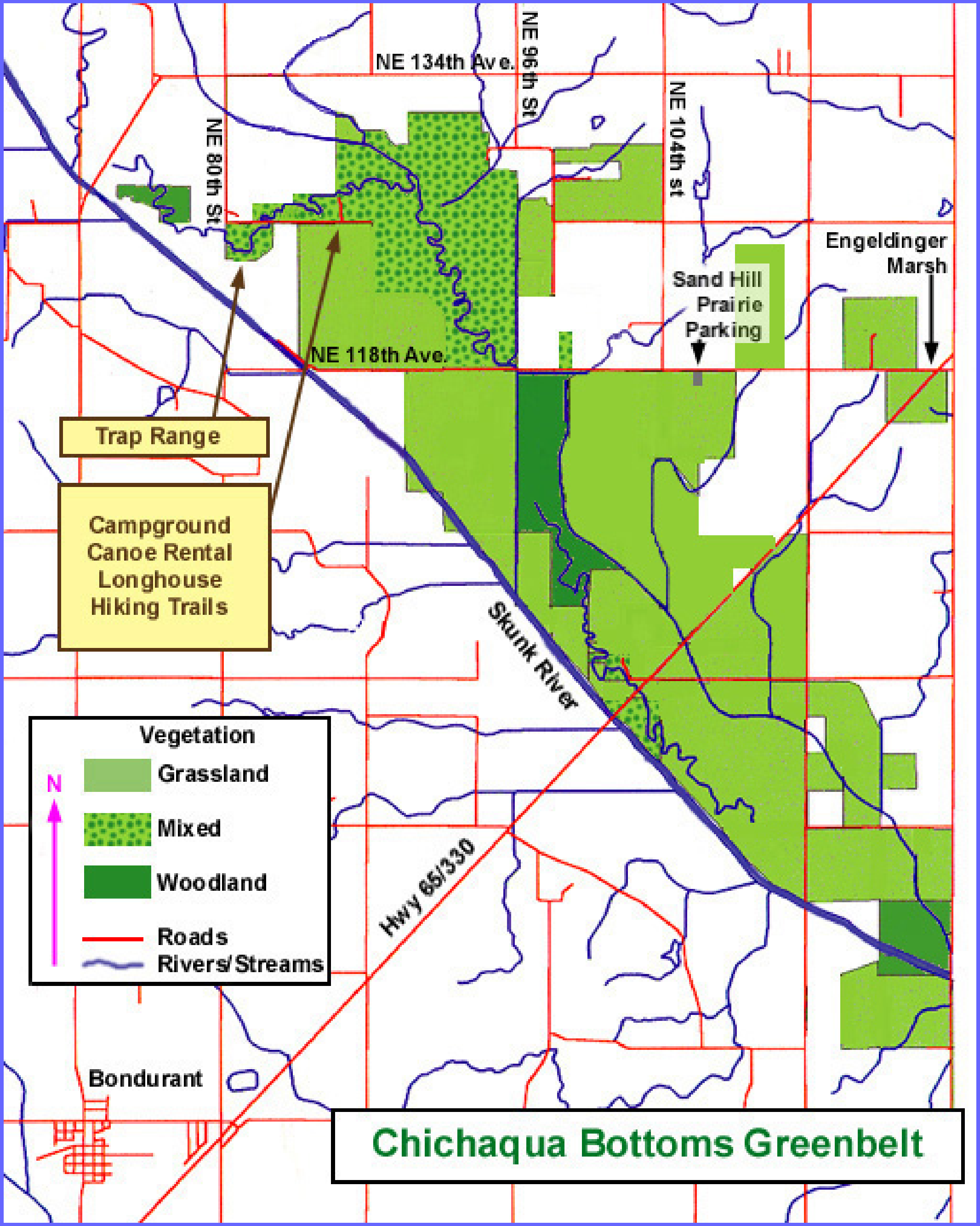


Water Quality Monitoring Stations at DD, ZN, Z, SLCC. Automated collection of water quality information and water samples for nutrient analysis. Real time data viewed and collected at http://waterdata.usgs.gov/wi/nwis/current/?type=flow. Nutrient concentrations determined at UMESC and USEPA Labs.

Constituents Sampled In Water

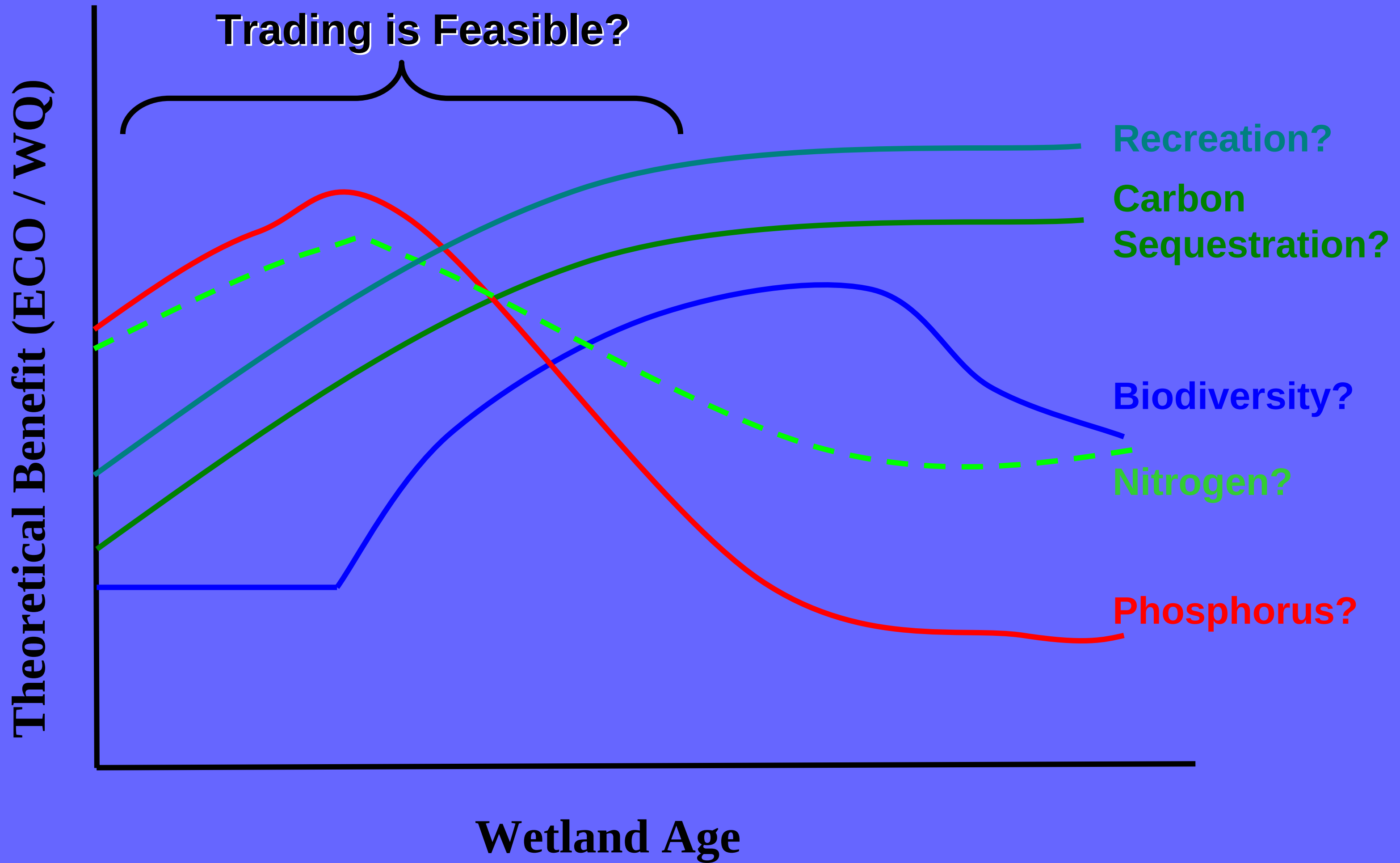
- Suspended Solids
- Total Solids
- Suspended Sediment
- Total Phosphorus
- Total Dissolved Phosphorus
- Dissolved Reactive Phosphorus (ortho-p)
- Dissolved Ammonia
- Dissolved Nitrate + Nitrite
- Total Kjeldahl Nitrogen
- Total Kjeldahl Nitrogen - Dissolved
- Bacteria


Outlet to Lake Onalaska (Miss. R.)
Site Z


NE 134th Ave.
NE 96th St
NE 104th st
NE 80th St
Engeldinger Marsh
Sand Hill Prairie Parking
NE 118th Ave.
Trap Range
Campground
Canoe Rental
Longhouse
Hiking Trails
Skunk River
Vegetation
N
Grassland
Mixed
Woodland
Roads
Rivers/Streams
Hwy 65/330
Bondurant
Chichaqua Bottoms Greenbelt

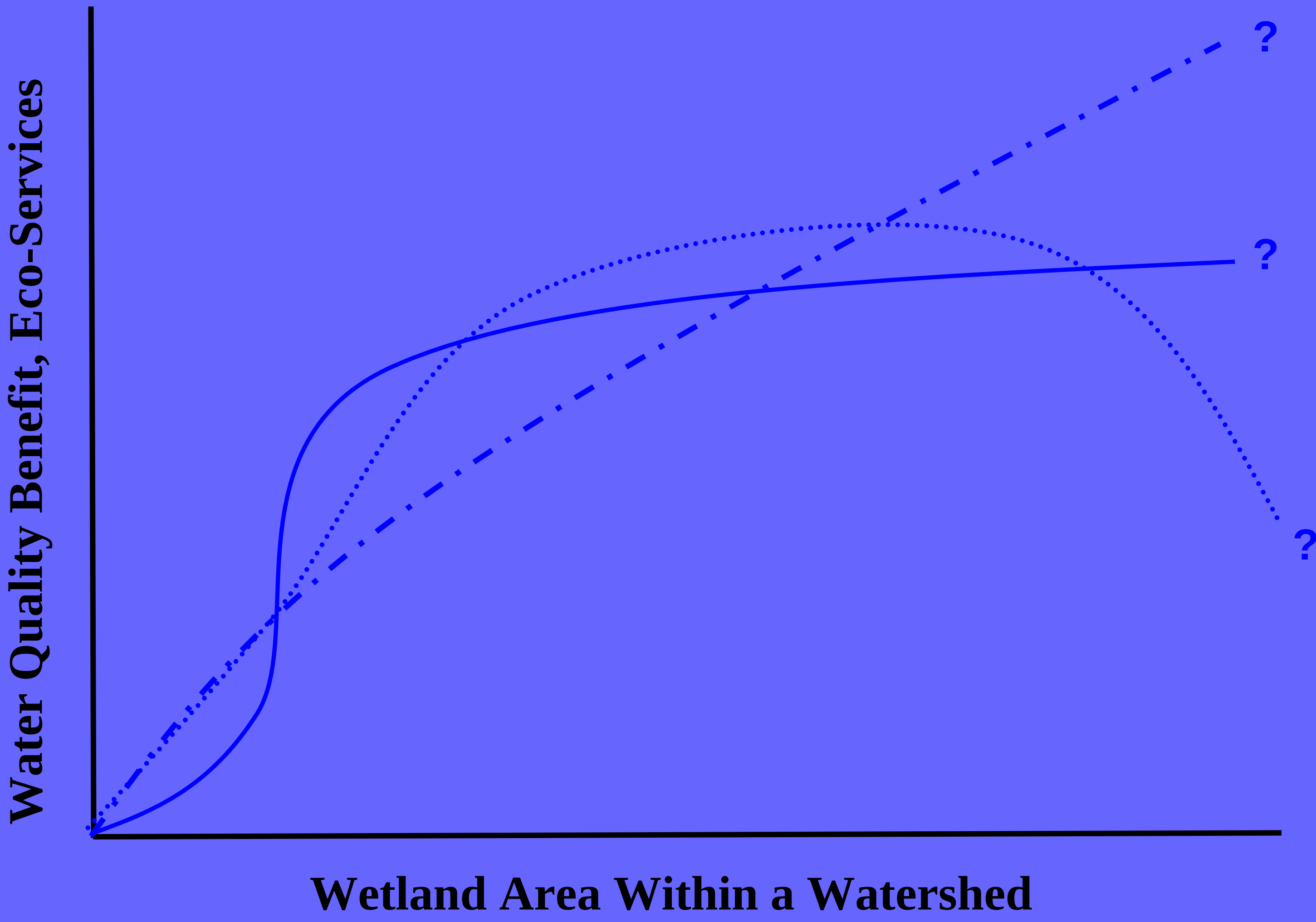
Bailey-Carpenter WRP IA

Wetland Benefit Curves: How do we account for composite and ancillary benefits over time?



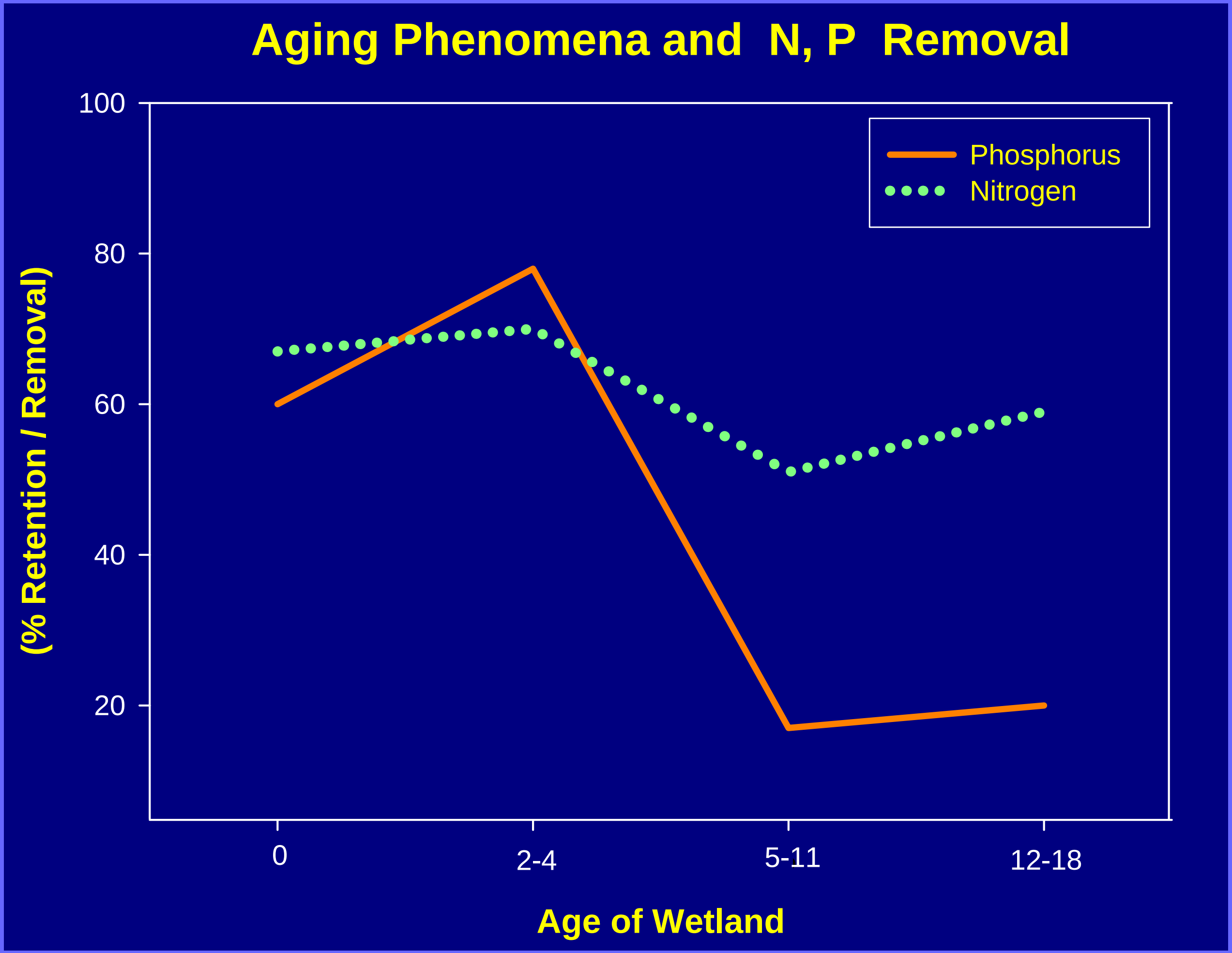
Other key factors: wetland type (template) wetland size, loading rates, watershed area/position

For example: What is the relationship between Wetland Area and Water Quality Benefit?



How might WQ Benefits vary with Wetland Age?

(Field data for Wetland Functional Trajectory)



Curves for N and P Removal Based on Data from a Literature Review

From Craft and Schubauer-Berigan 2007 ; Pages: 143-158, In: Innovations in Reducing Nonpoint Source Pollution: Methods, Policies, Programs and Measurements. Dennis Wichelns (ed.), River's Institute at Hanover College, Hanover, IN. Adapted from Nichols and Higgins (2000). Journal of Environmental Quality29:1703-1704.

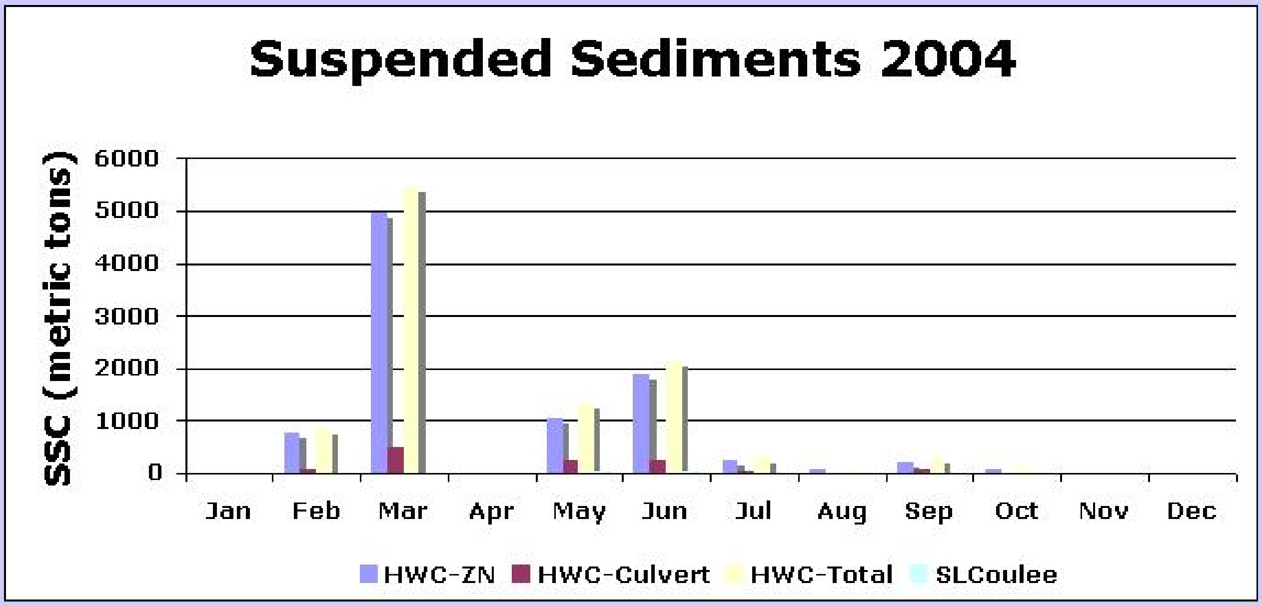
During late summer 2005 ~2500 cubic yards of sediment were removed from Pool A, at no cost, by a landscape company. We estimate there was also 6741 kg of N and 2667 kg P removed with the sediment.

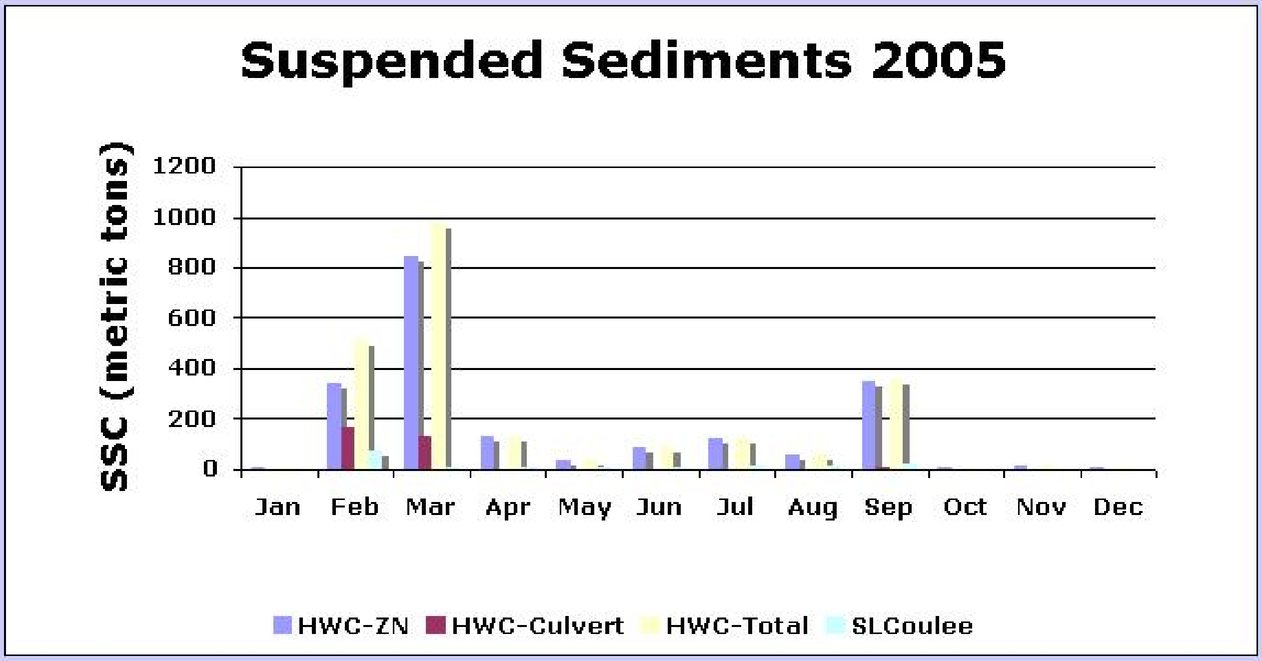
Current understanding from the literature

- Restored floodplain wetlands probably offer the best opportunities for use in a Water Quality Trading Program.

- Floodplain wetlands can remove around 200 kg N ha^{-1} annually, and up to 600 kg ha^{-1} yr under high nitrate loading rates.

- Long-term phosphorus removal is considerably less, 20 kg ha^{-1} yr^{-1}.


Suspended Sediments 2004
SSC (metric tons)
6000
5000
4000
3000
2000
1000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
HWC-ZN
HWC-Culvert
HWC-Total
SLCoulee


Suspended Sediments 2005
SSC (metric tons)
1200
1000
800
600
400
200
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
HWC-ZN
HWC-Culvert
HWC-Total
SLCoulee

Loads of suspended sediments (mtons), total N, and total P in Halfway Creek (ZN), Marsh Inlet, and Sand Lake Coulee Creek, (OT), February – September 2004

Site	Susp. Sed. (mtons)	Tot. N (kg)	Tot.P (kg)
ZN	4,417	37,720	7,691
Marsh Inlet	519	2,015	762
OT (SLCC)	85	693	133

Percent of sediment and nutrient load at each monitoring site. Note: “Marsh inlet” represents % of Creek load captured by Halfway Creek Marsh Pool A.

Site	Susp. Sed. %	Tot. N %	Tot.P %
ZN	88	93	90
Marsh Inlet**	10	5	9
OT (SLCC)	2	2	2

** % of load captured by marsh

% Watershed Annual Loads Removed By HWC Constructed & Natural Marshes

~66% Sediment

~61% Suspended Solids

~24% Total Phosphorus

~10% Total Nitrogen

Project Example for Wetland Template along stream corridor, Conservation: Managed Wetland with Diked, Controlled Flow

Microbial removal of Nitrogen

- Denitrification rates (microbial conversion of nitrate to N2 gas) were highest in the Natural Marsh, ~ half as high in the restored marsh, and low in the Creek sediments.

- Denitrification in Pool A removes a small fraction (488 kg during growing season) of the total N load.

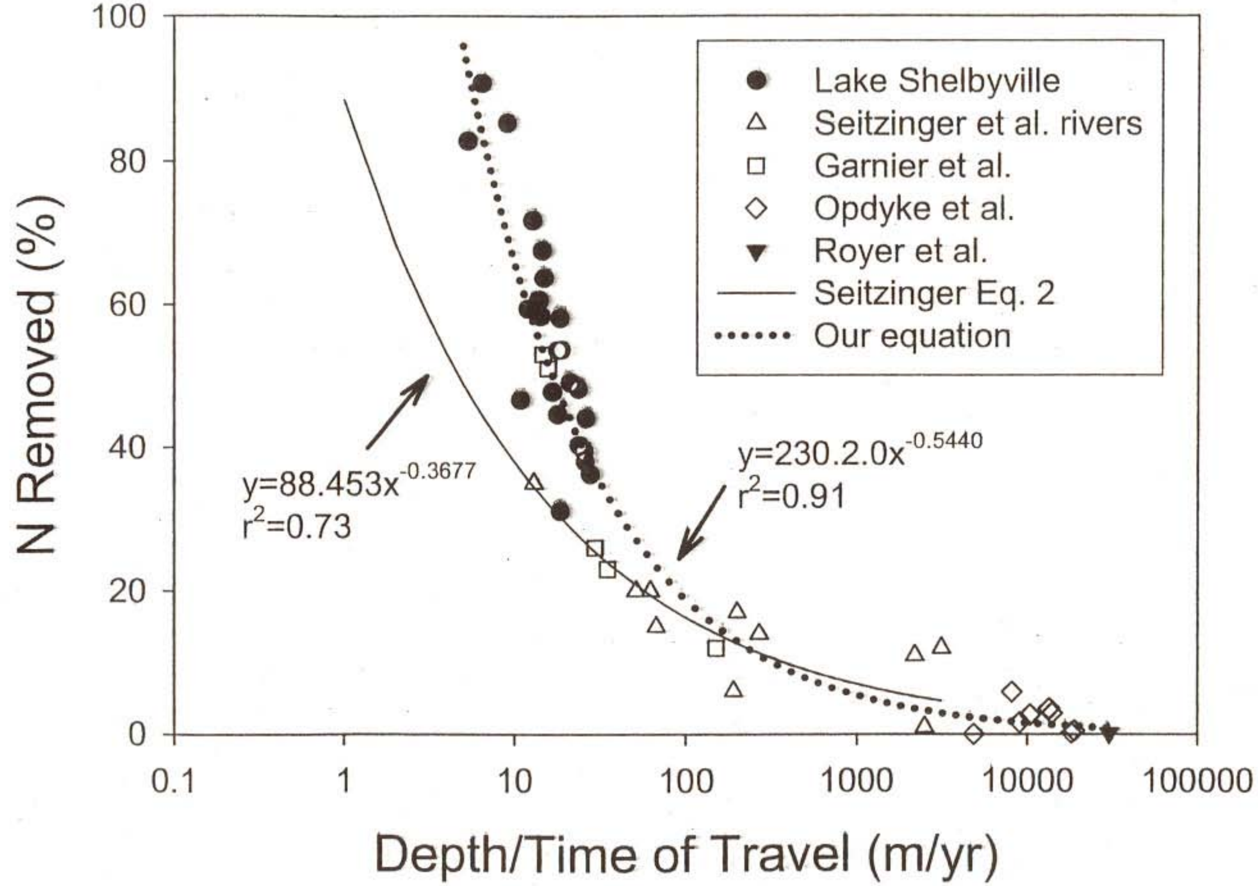


Figure 37: N removed in aquatic ecosystems (as a % of inputs) as a function of ecosystem depth/water travel time (modified from David et al., 2006). Values shown are for 23 years in an Illinois reservoir (David et al., 2006), French reservoirs (Garnier et al., 1999), Illinois streams (an average from Royer et al., 2004), agricultural streams (Opdyke et al., 2006), and rivers (Seitzinger et al., 2002). The curve from Seitzinger et al. (2002) is not as steep as the curve that includes information from reservoirs in an agricultural region.

Current Projects

- **Managed Wetland Diked Controlled Flow**
  - USFWS, La Crosse, WI
  - Great Salt Lake wetlands
  - NRCS, CREP and WRP, IA

- **Large River Channel Restored Wetlands**
  - Illinois River (Hey *et al*.) *
  - The Nature Conservancy, Emiquon, *

** Technical support role for USEPA R5*